Variational Multiscale Finite Element Method in Computational Fluid Dynamics

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Overview

Variational Multiscae (VMS) Finite Element (FE) methods are proposed to solve some problems appearing in Computational Fluid Dynamics (CFD). Since its introduction in the 90s in (Hughes, 1995, Hughes, Feijoo and Quincy (98) etc), the VMS framework has been applied to designed STABILIZED FE Methods in problems wherein stability of the standard Galerkin Method is not ensured. This may be mapped to the following two reasons: a) singularly perturbed problems require extremely fine meshes, unaffordable in most cases from the computational point of view, to attain stability bounds numerically meaningful and leading to convergence; inflow problems, the paradigmatic example of this case is the convection-diffusion equation in the convection-dominated limit and (b) in mixed problems involving variables of different nature, the FE spacaces chosen to approximate them need to satisfy compatibility conditions to render the problem stable, i.e. satisfying the necessary and sufficient inf-sup condition for stability; the most well known example of this situation in fluid mechanics is the Stokes Problem. Both the instabilities related to singular perturbations and to compatibility conditions of the interpolation can be overcome by resorting to Stabilized FE Methods. Stabilization is a broad term that encompasses many numerical techniques.

As such VMS is more like a general framework. Under this concept the essential unknown, say u, is split into two parts, say $\bar{u}\ and\ u'$, where the component $\bar{u}$ is resolvable by regular FE-space and the other component u' is resolved on a subgrid scale or subscale. Different numerical methods can be obtained when subgrid scales are approximated. VMS approach is useful in solving a broad spectrum of problems such as compressible/incompressible flows, low Mach number flows, flows in porous media, wave problems, magneto-hydrodynamics, Electro-Magnetic problems etc. from different branches of science and engineering

.This course is organized in two modules that should be taken together. The topics in Module A will expose the participants to the basics of Fluid Mechanic and Finite Element Method. This will also be supplemented with introduction to FANTOM software for FE Computations and practice Lab sessions. Module B will be focused on the VMS-FEM for CFD studies.

Course participants will learn these topics through lectures and hands-on lab sessions. Also case studies and assignments will be shared to stimulate research motivation of participants.

Modules	**A: BASICS of FM & FEM : May 04 - May 07** **B: VMS-FEM & Application to Fluid Flows : May 08 - May 14** **Number of participants for the course will be limited to Forty.**
You Should Attend If…	▪ You are a student or faculty from academic institution interested in learning VMS-FEM for Fluid Flow Studies. ▪ You already have exposure to Fluid Mechanics, Basic FEM and Programming
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $500** **Industry/ Research Organizations: ` 30000** **Academic Institutions: ` 10000** The above fee includes all instructional materials, computer use for tutorials and assignments, internet facility. The participants will be provided with accommodation on payment basis.

The Faculty

Prof. Ramon Codina is in the faculty of Universitat Politecnica de Catalunya (UPC) in Spain. His research interests include numerical methods in engineering and applied sciences, with particular emphasis on finite element methods in fluid mechanics .

Prof. B.V. Rathish Kumar is in the faculty of Indian Institute of Technology Kanpur. His research interests include numerical methods for Partial Differential Equations, with particular emphasis on finite element methods in fluid mechanics & Heat Transfer .

Course Co-ordinator

Prof. B.V.Rathish Kumar
Phone: 0512-259 7660/7636
E-mail: vms.fem.iitk@gmail.com

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http://www.gian.iitkgp.ac.in/VMSFEM